

## CLAIMS

- 1 1. A computer system configured by machine instructions as a garbage collector  
2 that:
- 3 A) treats at least a generation of a heap in which objects are dynamically allo-  
4 cated as divided into regions;
- 5 B) collects in respective collection increments collection sets chosen in ac-  
6 cordance with respective estimated collection efficiencies from among a  
7 candidate set of the regions; and
- 8 C) in at least one mode of operation, so places dynamically allocated objects  
9 that no candidate-set region that contains an object whose age is less than  
10 a maximum age greater than one also contains any object of a different  
11 age.
- 1 2. A computer system as defined in claim 1 wherein the maximum age is two.
- 1 3. A computer system as defined in claim 1 wherein the garbage collector assigns  
2 respective age values to the regions without recording ages separately for all dynamically  
3 allocated objects, the age assigned each region into which the collector evacuates poten-  
4 tially reachable objects from a collection-set region assigned an age less than the maxi-  
5 mum age being one greater than the age assigned to that collection-set region.
- 1 4. A computer system configured by machine instructions as a garbage collector  
2 that:
- 3 A) treats at least a generation of a heap in which objects are dynamically allo-  
4 cated as divided into regions;
- 5 B) collects in respective collection increments collection sets chosen, in ac-  
6 cordance with a selection criteria separate from object age, from among a  
7 candidate set of the regions; and

8           C)     in at least one mode of operation, so places dynamically allocated objects  
9                   that no candidate-set region that contains an object whose age is less than  
10                  a maximum age greater than one also contains any object of a different  
11                  age.

1     5.     A computer system as defined in claim 4 wherein the maximum age is two.

1     6.     A computer system as defined in claim 4 wherein the garbage collector assigns  
2     respective age values to the regions without recording ages separately for all dynamically  
3     allocated objects, the age assigned each region into which the collector evacuates poten-  
4     tially reachable objects from a collection-set region assigned an age less than the maxi-  
5     mum age being one greater than the age assigned to that collection-set region.

1     7.     A computer system configured by machine instructions as a garbage collector  
2     that:

3           A)     treats at least a generation of a heap in which objects are dynamically allo-  
4                  cated as divided into regions;

5           B)     collects in respective collection increments collection sets chosen from  
6                  among a candidate set of the regions in accordance with such a selection  
7                  criterion that the resultant collection set sometimes includes a region  
8                  whose age is less than that of a region in the candidate set omitted from  
9                  the collection set and sometimes includes a region whose age is greater  
10                 than that of a region that was in the candidate set but was omitted from the  
11                 collection set; and

12          C)     in at least one mode of operation, so places dynamically allocated objects  
13                  that no candidate-set region that contains an object whose age is less than  
14                  a maximum age greater than one also contains any object of a different  
15                  age.

1     8.     A computer system as defined in claim 7 wherein the maximum age is two.

1     9.     A computer system as defined in claim 7 wherein the garbage collector assigns  
2     respective age values to the regions without recording ages separately for all dynamically  
3     allocated objects, the age assigned each region into which the collector evacuates poten-  
4     tially reachable objects from a collection-set region assigned an age less than the maxi-  
5     mum age being one greater than the age assigned to that collection-set region.

1     10.    For reclaiming dynamically allocated memory in a computer system, a method  
2     comprising employing the computer system to:

- 3         A)     treat at least a generation of a heap in which objects are dynamically allo-  
4                cated as divided into regions;
- 5         B)     collect in respective collection increments collection sets chosen in accor-  
6                dance with respective estimated collection efficiencies from among a can-  
7                didate set of the regions; and
- 8         C)     in at least one mode of operation, so place dynamically allocated objects  
9                that no candidate-set region that contains an object whose age is less than  
10               a maximum age greater than one also contains any object of a different  
11               age.

1     11.    A method as defined in claim 10 wherein the maximum age is two.

1     12.    A method as defined in claim 10 wherein respective age values are assigned to the  
2     regions without recording ages separately for all dynamically allocated objects, the age  
3     assigned each region into which the collector evacuates potentially reachable objects  
4     from a collection-set region assigned an age less than the maximum age being one greater  
5     than the age assigned to that collection-set region.

- 1    13.    For reclaiming dynamically allocated memory in a computer system, a method  
2    comprising employing the computer system to:
- 3            A)    treat at least a generation of a heap in which objects are dynamically allo-  
4                    cated as divided into regions;
- 5            B)    collect in respective collection increments collection sets chosen, in accor-  
6                    dance with a selection criteria separate from object age, from among a  
7                    candidate set of the regions; and
- 8            C)    in at least one mode of operation, so place dynamically allocated objects  
9                    that no candidate-set region that contains an object whose age is less than  
10                  a maximum age greater than one also contains any object of a different  
11                  age.
- 1    14.    A method as defined in claim 13 wherein the maximum age is two.
- 1    15.    A method as defined in claim 13 wherein respective age values are assigned to the  
2    regions without recording ages separately for all dynamically allocated objects, the age  
3    assigned each region into which the collector evacuates potentially reachable objects  
4    from a collection-set region assigned an age less than the maximum age being one greater  
5    than the age assigned to that collection-set region.
- 1    16.    For reclaiming dynamically allocated memory in a computer system, a method  
2    comprising employing the computer system to:
- 3            A)    treat at least a generation of a heap in which objects are dynamically allo-  
4                    cated as divided into regions;
- 5            B)    collect in respective collection increments collection sets chosen from  
6                    among a candidate set of the regions in accordance with such a selection  
7                    criterion that the resultant collection set sometimes includes a region  
8                    whose age is less than that of a region in the candidate set omitted from  
9                    the collection set and sometimes includes a region whose age is greater

10           than that of a region that was in the candidate set but was omitted from the  
11           collection set; and

12           C)    in at least one mode of operation, so place dynamically allocated objects  
13           that no candidate-set region that contains an object whose age is less than  
14           a maximum age greater than one also contains any object of a different  
15           age.

1    17.    A method as defined in claim 16 wherein the maximum age is two.

1    18.    A method as defined in claim 16 wherein respective age values are assigned to the  
2    regions without recording ages separately for all dynamically allocated objects, the age  
3    assigned each region into which the collector evacuates potentially reachable objects  
4    from a collection-set region assigned an age less than the maximum age being one greater  
5    than the age assigned to that collection-set region.

1    19.    A storage medium containing computer instructions readable by a computer sys-  
2    tem to configure the computer system as a garbage collector that:

3           A)    treats at least a generation of a heap in which objects are dynamically allo-  
4           cated as divided into regions;

5           B)    collects in respective collection increments collection sets chosen in ac-  
6           cordance with respective estimated collection efficiencies from among a  
7           candidate set of the regions; and

8           C)    in at least one mode of operation, so places dynamically allocated objects  
9           that no candidate-set region that contains an object whose age is less than  
10          a maximum age greater than one also contains any object of a different  
11          age.

1    20.    A storage medium as defined in claim 19 wherein the maximum age is two.

1 21. A storage medium as defined in claim 19 wherein the garbage collector assigns  
2 respective age values to the regions without recording ages separately for all dynamically  
3 allocated objects, the age assigned each region into which the collector evacuates poten-  
4 tially reachable objects from a collection-set region assigned an age less than the maxi-  
5 mum age being one greater than the age assigned to that collection-set region.

1 22. A storage medium containing computer instructions readable by a computer sys-  
2 tem to configure the computer system as a garbage collector that:

- 3 A) treats at least a generation of a heap in which objects are dynamically allo-  
4 cated as divided into regions;
- 5 B) collects in respective collection increments collection sets chosen, in ac-  
6 cordance with a selection criteria separate from object age, from among a  
7 candidate set of the regions; and
- 8 C) in at least one mode of operation, so places dynamically allocated objects  
9 that no candidate-set region that contains an object whose age is less than  
10 a maximum age greater than one also contains any object of a different  
11 age.

1 23. A storage medium as defined in claim 22 wherein the maximum age is two.

1 24. A storage medium as defined in claim 22 wherein the garbage collector assigns  
2 respective age values to the regions without recording ages separately for all dynamically  
3 allocated objects, the age assigned each region into which the collector evacuates poten-  
4 tially reachable objects from a collection-set region assigned an age less than the maxi-  
5 mum age being one greater than the age assigned to that collection-set region.

1 25. A storage medium containing computer instructions readable by a computer sys-  
2 tem to configure the computer system as a garbage collector that:

- 3 A) treats at least a generation of a heap in which objects are dynamically allo-  
4 cated as divided into regions;

- 5           B)     collects in respective collection increments collection sets chosen from  
6                     among a candidate set of the regions in accordance with such a selection  
7                     criterion that the resultant collection set sometimes includes a region  
8                     whose age is less than that of a region in the candidate set omitted from  
9                     the collection set and sometimes includes a region whose age is greater  
10                    than that of a region that was in the candidate set but was omitted from the  
11                    collection set; and  
12           C)     in at least one mode of operation, so places dynamically allocated objects  
13                    that no candidate-set region that contains an object whose age is less than  
14                    a maximum age greater than one also contains any object of a different  
15                    age.

1   26.     A storage medium as defined in claim 25 wherein the maximum age is two.

1   27.     A storage medium as defined in claim 25 wherein the garbage collector assigns  
2     respective age values to the regions without recording ages separately for all dynamically  
3     allocated objects, the age assigned each region into which the collector evacuates poten-  
4     tially reachable objects from a collection-set region assigned an age less than the maxi-  
5     mum age being one greater than the age assigned to that collection-set region.

1   28.     An electromagnetic signal representing computer instructions readable by a com-  
2     puter system to configure the computer system as a garbage collector that:

- 3           A)     treats at least a generation of a heap in which objects are dynamically allo-  
4                    cated as divided into regions;  
5           B)     collects in respective collection increments collection sets chosen in ac-  
6                    cordance with respective estimated collection efficiencies from among a  
7                    candidate set of the regions; and  
8           C)     in at least one mode of operation, so places dynamically allocated objects  
9                    that no candidate-set region that contains an object whose age is less than

10                   a maximum age greater than one also contains any object of a different  
11                   age.

1    29.    An electromagnetic signal as defined in claim 28 wherein the maximum age is  
2    two.

1    30.    An electromagnetic signal as defined in claim 28 wherein the garbage collector  
2    assigns respective age values to the regions without recording ages separately for all dy-  
3    namically allocated objects, the age assigned each region into which the collector evacu-  
4    ates potentially reachable objects from a collection-set region assigned an age less than  
5    the maximum age being one greater than the age assigned to that collection-set region.

1    31.    An electromagnetic signal representing computer instructions readable by a com-  
2    puter system to configure the computer system as a garbage collector that:  
3           A)    treats at least a generation of a heap in which objects are dynamically allo-  
4                cated as divided into regions;  
5           B)    collects in respective collection increments collection sets chosen, in ac-  
6                cordance with a selection criteria separate from object age, from among a  
7                candidate set of the regions; and  
8           C)    in at least one mode of operation, so places dynamically allocated objects  
9                that no candidate-set region that contains an object whose age is less than  
10               a maximum age greater than one also contains any object of a different  
11               age.

1    32.    An electromagnetic signal as defined in claim 31 wherein the maximum age is  
2    two.

1    33.    An electromagnetic signal as defined in claim 31 wherein the garbage collector  
2    assigns respective age values to the regions without recording ages separately for all dy-  
3    namically allocated objects, the age assigned each region into which the collector evacu-



4     ates potentially reachable objects from a collection-set region assigned an age less than  
5     the maximum age being one greater than the age assigned to that collection-set region.

1     34.     An electromagnetic signal representing computer instructions readable by a com-  
2     puter system to configure the computer system as a garbage collector that:

3             A)     treats at least a generation of a heap in which objects are dynamically allo-  
4                     cated as divided into regions;

5             B)     collects in respective collection increments collection sets chosen from  
6                     among a candidate set of the regions in accordance with such a selection  
7                     criterion that the resultant collection set sometimes includes a region  
8                     whose age is less than that of a region in the candidate set omitted from  
9                     the collection set and sometimes includes a region whose age is greater  
10                    than that of a region that was in the candidate set but was omitted from the  
11                    collection set; and

12            C)     in at least one mode of operation, so places dynamically allocated objects  
13                     that no candidate-set region that contains an object whose age is less than  
14                     a maximum age greater than one also contains any object of a different  
15                     age.

1     35.     An electromagnetic signal as defined in claim 34 wherein the maximum age is  
2     two.

1     36.     An electromagnetic signal as defined in claim 34 wherein the garbage collector  
2     assigns respective age values to the regions without recording ages separately for all dy-  
3     namically allocated objects, the age assigned each region into which the collector evacu-  
4     ates potentially reachable objects from a collection-set region assigned an age less than  
5     the maximum age being one greater than the age assigned to that collection-set region.

- 1 37. A garbage collector comprising:
- 2 A) means for treating at least a generation of a heap in which objects are dy-
- 3 namically allocated as divided into regions;
- 4 B) means for collecting in respective collection increments collection sets
- 5 chosen in accordance with respective estimated collection efficiencies
- 6 from among a candidate set of the regions; and
- 7 C) means for, in at least one mode of operation, so placing dynamically allo-
- 8 cated objects that no candidate-set region that contains an object whose
- 9 age is less than a maximum age greater than one also contains any object
- 10 of a different age.

- 1 38. A garbage collector comprising:
- 2 A) means for treating at least a generation of a heap in which objects are dy-
- 3 namically allocated as divided into regions;
- 4 B) means for collecting in respective collection increments collection sets
- 5 chosen, in accordance with a selection criteria separate from object age,
- 6 from among a candidate set of the regions; and
- 7 C) means for, in at least one mode of operation, so placing dynamically allo-
- 8 cated objects that no candidate-set region that contains an object whose
- 9 age is less than a maximum age greater than one also contains any object
- 10 of a different age.

- 1 39. A garbage collector comprising:
- 2 A) means for treating at least a generation of a heap in which objects are dy-
- 3 namically allocated as divided into regions;
- 4 B) means for collecting in respective collection increments collection sets
- 5 chosen from among a candidate set of the regions in accordance with such
- 6 a selection criterion that the resultant collection set sometimes includes a
- 7 region whose age is less than that of a region in the candidate set omitted
- 8 from the collection set and sometimes includes a region whose age is

9 greater than that of a region that was in the candidate set but was omitted  
10 from the collection set; and  
11 C) means for, in at least one mode of operation, so placing dynamically allo-  
12 cated objects that no candidate-set region that contains an object whose  
13 age is less than a maximum age greater than one also contains any object  
14 of a different age.